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Harnessing Science and Technology for Agricultural Development in Mali Under the Initiative to End Hunger in Africa
USAID/MALI EXPERT CONSULTATION TEAM
SECTOR REPORTS: AGRICULTURAL PRODUCTION

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CONCEPTUAL FRAMEWORK FOR EFFECTIVE TECHNOLOGY DEVELOPMENT PLANNING

A conceptual framework for use by science and technology decision makers that ensures appropriate consideration of market demand during technology development planning uses a market-led, agribusiness commodity systems approach. An agribusiness "system" can be defined as all the steps in the chain of events that are required to produce, transform, market, and distribute an agricultural commodity. The agribusiness system starts with the genetic material used for seed stock and continues all the way through the chain of events until the final product is delivered to the customer. The commodity produced, or the product derived from that commodity, fills a market need. "Market-led" means there is a home for the product being offered in whatever form the market requires, where the volume of the product can be sold over a defined seasonal period, and the price received is sufficient to be profitable after deducting all real costs.

The agribusiness systems approach can be used to develop specific marketable commodities or final agricultural products for which Mali has a competitive advantage. Well-developed agribusiness systems are typically composed of different players who are responsible for different links in the chain of events required to produce, transform and market a product. This chain of events is often referred to as the "value chain" for a product or commodity.

Traditionally, agri-food commodities are undifferentiated and move through the system using arms length transactions. For example, a farmer may sell a commodity at farm gate. It is consolidated by a consolidator and sold to a third party at a packing house or processing plant. Producing a consumer product in modern agriculture may involve producing a long sequence of intermediate products. Each one is used as an ingredient or raw material to make the next product in the sequence. This is the meaning of the term value added, because value is added at each step.

Instead of all the products being produced by one farm family, many different agribusinesses are normally involved. These include companies directly involved in the process, such as seed companies, fertilizer suppliers, and commercial traders. But supporting each of these groups in the system are agricultural researchers, financial institutions, equipment suppliers, farmers' associations, government agencies, and agriculture universities.

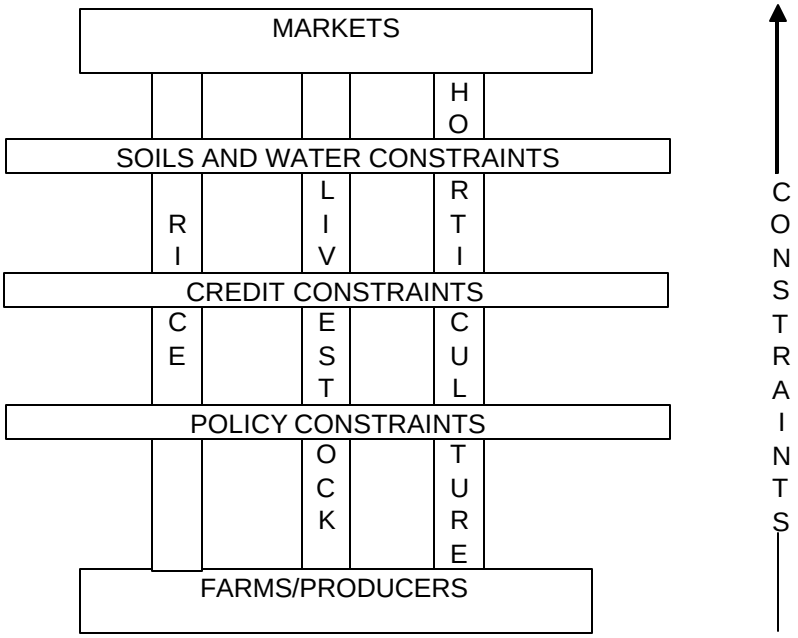
By focusing the use of science and technology on solving problems and removing constraints within the value chain for creating a particular product that can be sold profitably in a given market, these become tools that help to fill a market need and thereby give appropriate consideration to market demand. In this sense, science and technology products are used to serve the market. They become responsive to market demand. If science and technology are designed to serve commercial purposes, then public-private partnerships quickly evolve for the purpose of applying in the private sector the knowledge that may be gained in the public sector.

The following diagram depicts the agribusiness systems approach for the three sub-sectors that were targeted in USAID/Mali's 2003 – 2012 Country Strategic Plan: rice, livestock, and horticulture. Development of these sub-sectors is not only constrained by

factors within the respective value chains for each sub-sector, but they are also hampered by cross-cutting constraints such as soils and water constraints, credit, and adverse government policies and regulations.

In addition to using science and technology providing support to the development of specific agro-industries, they can also be used to overcome those cross-cutting constraints that affect all sectors. The main cross-cutting constraints in Mali are a) the limited availability of suitable soils and water, particularly irrigated areas, b) limited credit, and c) policies that adversely affect the agribusiness climate.

The Use of Agribusiness Systems for Technology Development Planning



Soils and Water: The potential for productivity enhancement through irrigation investments on suitable soils is enormous. Risk is reduced for the small holder participants because they are no longer as dependent on rainfall. Risk is reduced for the economy as a whole as well, because the overall market basket becomes somewhat less vulnerable to rainfall variability. The productivity enhancement is obvious - crop yields will be multiplied many fold in the irrigated zones.

Credit: The lack of credit is particularly acute in rural areas in Mali. The greatest need is for crop loans that permit small holders to buy seed, fertilizer and other inputs at the beginning of the season, with the loans to be repaid at the end of the season. Most small holders and small traders cannot get access to credit in the commercial banking sector. In limited cases, banks will make loans to a village association against the production of high value crops by its members. In other cases, micro-finance institutions (MFIs) provide group loans to farmers' associations. Longer term investment loans must generally be supported by collateral, such as a building or a land title.

Government policies: Establishing a transparent and objective regulatory environment is the only way to effectively develop market opportunities and promote long-term private sector investment. In the past, particularly harmful policies were those that impeded the private, long term use of land, and consequently investment, in irrigated areas. However, the recent change by the *Office du Niger* (ON) to allow 99-year lease under the *bail emphytéotique* (lease arrangement) is a policy change that should improve the rural investment climate over the long term.

A description of how science and technology tools can be used for the development of a particular agribusiness – tomato production - is described in the next section. This will provide an example of how science and technology interventions can be used to help the development of this potentially important crop. Tomatoes were selected as a suitable agro-industry for this analysis by the USAID Mission in Bamako.

THE TOMATO SUB-SECTOR IN MALI

According to information from the *Direction Nationale de l'Appui au Monde Rural* (DNAMR), the annual volume of fresh tomatoes produced in Mali for commercial use is approximately 24,000 tons. The total area in production is approximately 1,400 hectares, and the average yield is about 17 tons per hectare. Commercial tomatoes are produced mainly within two irrigation zones: at Niono, in the Ségou region, within the irrigated area controlled by the *Office du Niger* (ON), and within the Koulikoro region at Baguineda within the irrigation scheme managed by the *Office de la Haute Vallée du Niger* (OHVN). Similar to the production season for many other horticulture products, most tomatoes are cultivated during the "contre-saison" between January and June. The main harvest period falls between April and June. Several varieties are used, but the "industrial" or processing varieties of tomatoes are preferred by traders since they are able to withstand handling and transport damage better than other varieties that are more fragile. Unlike potatoes, which is a crop that tends to be produced mostly by men, in Mali tomatoes are traditionally cultivated and harvested by women.

The primary constraints to tomato production and marketing are the following:

- There is a lack of improved plant varieties
- There is a lack of virus-resistant plant varieties, especially in virus-infested areas such as Baguineda, within the OHVN irrigation areas.
- There are no available cold storage facilities for storing fresh tomatoes, either in the producing areas or at the urban markets.
- Packaging is inadequate. This problem, combined with poor roads and unsuitable transportation causes heavy losses.
- Producer credit is generally not available.

Fresh tomato production is highly seasonal, with wide fluctuations in price. During the height of the production season, the price can dip as low as 10 – 20 FCFA per kilogram. In the low production season, the price may reach as high as 375 – 400 FCFA per kilogram.

The market circuit or "system" is quite simple: Tomatoes are harvested and held under shade in the village until the trader/consolidator arrives. The trader buys the tomatoes from individual farmers, at the price specified by the trader. There is hardly any joint marketing of horticultural crops, and farmers rarely organize themselves to jointly deliver their horticultural products to the market. In some cases, depending on the distance to the weekly market held in a nearby town, individual farmers may deliver cart loads of tomatoes to the market. Tomatoes purchased from the farmers by the traders are transported in large, bowl-shaped baskets, often stacked within the cart with other fresh horticultural products, and delivered to a weekly wholesale market where they are sold to a wholesaler. The wholesaler will consolidate the purchases into larger quantities and transport the entire load into major fresh produce markets near Bamako or Sicasso. There, baskets of fresh tomatoes are sold to retailers, who are normally female vendors who sell from market stalls or from a street location.

With the closure of the tomato paste processing plant in 1998, almost all tomatoes are sold fresh at urban markets. However, small amounts of tomatoes are reported to be dried under artisan methods within the location known as the Cercle de Kita.

The following are recommended uses of science and technology for the development of the fresh tomato sub-sector in Mali. Recommendations for the short term are presented as a means to improve the availability and marketability of fresh tomatoes for urban markets within Mali.

Recommendations for the longer term are geared toward providing access to sub-regional markets for Mali fresh tomatoes.

Recommendations for the short term:

a) *Rapid introduction of tomato yellow leaf curl virus (TYLCV)–resistant varieties*: It is recommended that work now underway by the field offices of the Institut d'Economie Rurale (IER) to identify and field test tomato varieties that are resistant to TYLCV be accelerated. This is a major problem in many tomato growing areas within Mali, especially in the Baguineda district. Without virus-resistant varieties, there will be little chance of developing the tomato agro-industry in Mali.

b) *Tomato varieties and agricultural practices suitable for year-round production*: While there is a year-round demand for fresh tomatoes in Mali, production is irregular and inconsistent, which results in wide fluctuation in the available supply and consequently, in the market price for fresh tomatoes. Lowest prices are normally registered in May, at around 90 FCFA per kilogram, whereas the highest prices are reported to occur in August, at 350 FCFA per kilogram. By conducting adaptive research on plant varieties and agricultural practices designed to provide tomatoes year round under different growing conditions, farmers and consumers alike would greatly benefit from relatively constant supplies and more even prices. This may require the introduction of tomato cultivation in non-traditional locations.

c) *Develop a reusable box to protect tomatoes during transport*: Post harvest losses for perishable products such as tomatoes can reach 35 percent under conditions such as those found in Mali. An interview with a Bamako tomato retailer on a particularly hot day revealed that losses often reach as high as 50 percent. The baskets that are used for transporting tomatoes are entirely unsuited for a delicate product that can be easily crushed. An excellent use of S&T to reduce post-harvest tomato losses would be to develop a low-cost, reusable container using indigenous materials to store and transport tomatoes under actual field conditions in Mali.

d) *Help producer groups to establish marketing associations for tomatoes:* Through joint marketing, tomato producers could most likely gain a price advantage and achieve a greater added value for their tomatoes. These principles have shown positive results in other countries, and should be highly adaptable for Mali.

Recommendations for longer term development of the fresh tomato agro-industry in Mali are the following:

Over the longer term, Malian exporters should be able to export fresh tomatoes to markets within the sub-region. Technology for doing this is readily available in other parts of the world, and can be easily adapted to conditions in Mali. This will require that four elements be in place: a) grades and standards, b) the ability to grade and sort fresh tomatoes to meet the grades and standards, c) packaging material to protect the tomatoes during handling and transit, and d) a "cold chain" suitable for a highly perishable product.

e) *Grades and standards*: Grades and standards help to facilitate the marketing process, since the buyer and seller alike are aware of what is being offered for sale, through the simple process of classifying the product. Essentially, grades and standards are a tool for effective communications. Grades and standards for tomatoes in Mali could be easily developed. For example, the United States Department of Agriculture (USDA) provides

grades and standards[1] for US tomato producers, packers, and buyers, which could easily be adapted to Mali.

f) *Grading and sorting*: One requirement for the export of fresh tomatoes is the capability to sort tomatoes into different sizes, such as small, medium and large, and to classify the sorted tomatoes into different product qualities, based on known standards. Tomato quality standards are based primarily on the shape of the fruit, physical damage, and external blemishes. A sorting and grading station is a requirement for tomato exports. Best suited for conditions in Mali would be a simple work station where workers manually select tomatoes meeting quality specifications from a moving belt.

g) *Packaging*: After fresh tomatoes have been graded and sorted, they must be packaged to protect them from handling damage and from damage while in transit. Presently, fresh horticultural products in Mali are not packaged for protection during transit, and losses to most products are high. Export tomatoes for regional markets must be packed in protective cartons. Unfortunately, there is presently no available source of suitable packaging material within Mali, so packaging material must be imported from either the Ivory Coast or from Senegal.

h) Modern handling systems for fresh products, including tomatoes, require the use of wooden pallets. Pallets make it possible to efficiently move large stacks of boxes filled with fresh tomatoes, using a forklift machine. Pallets to be used for tomato exports must also be imported from the Ivory Coast.

i) *Refrigerated storage and transportation*: For a perishable product such as the tomato, refrigerated storage is essential. It is well known within the fresh produce industry that the sooner after harvest a product such as the fresh tomato is cooled to its optimum temperature, the longer will be its shelf life, which enhances its value to the buyer. A second rule for handling fresh produce is that once the product is cooled, the "cold chain" must remain unbroken (i.e. the product must not be allowed to become re-heated) or the freshness of the product will be lost. In Mali there is a requirement for chilling equipment to remove the field heat from fruit and vegetables immediately after harvest, and for refrigerated storage rooms where the products can be maintained cool until shipped. Refrigerated transport is also required, so trucks must have the capability of maintaining the product cool during transit. Under the "no re-heating" rule, fresh products must be kept refrigerated until they reach the consumer.

   The process of obtaining refrigerated storage for fresh products in Mali may be somewhat accelerated by donor activities. It is understood that the USAID-funded Trade Mali project expects to receive a grant during 2005 from the Government of Holland to construct a refrigerated warehouse for storing fresh mangos and other fruit for export to Europe. This facility might provide needed storage space for fresh tomatoes as well. Furthermore, the Canadian government is reported to be planning a large-scale project to provide refrigerated storage for vegetables such as shallots and onions. Possibly, this facility might also serve tomato exporters.

Processing tomatoes

The tomato agro-industry is a study in duality, with two distinct sub-sectors: fresh tomatoes and processing tomatoes. Not surprisingly, these two sub-sectors are entirely different throughout their respective value chains. For example, processing, or "industrial" tomatoes are special

[1]These are available at the website http://www.ams.usda.gov/standards/tomatfrh.pdf

varieties that are grown intensively, and will normally produce tomatoes at much higher yields than do fresh tomatoes. Furthermore, the percentage of soluble solid content in processing tomatoes is nearly double that of fresh tomatoes. As a result, a smaller amount of processing tomatoes is required to produce a kilo of tomato paste than would be needed to make the same amount of paste from fresh tomatoes. Processing tomatoes normally have around 6 percent solids, whereas fresh tomatoes have only about 3 percent solids. The remainder is water and consequently, the process of extracting the water from the solid particles to produce tomato paste is expensive. More water must be removed from fresh tomatoes than from processing tomatoes to make equal amounts of paste. Since water removal requires energy, and energy is costly, the manufacturing process to produce tomato paste from fresh tomatoes is more expensive than that for processing tomatoes.

While fresh tomato varieties are not desirable as processing tomatoes, the opposite situation does not hold: In Mali, tomatoes are consumed primarily as food condiments or sauces, and are not commonly consumed as a fresh fruit. Consequently, processing tomatoes could be easily sold into local markets. In fact, processing tomatoes are desirable because they are somewhat hardier than fresh varieties because they have tougher skin and can better withstand rough handling after being harvested.

Fresh-market tomatoes are sold through different distribution channels, normally at higher and more variable prices than industrial tomatoes due to larger production costs and greater market uncertainty. While fresh tomatoes are typically sold by the farmer at US $.55 - $.75 per kilogram in the United States, processing tomatoes are valued at about US $.07 per kilogram. In most tomato producing countries of Western Europe, as a result of government subsidies to their farmers, processing tomatoes are sold as little as US $.05 per kilogram.

The industrial tomato can be processed into a range of products, of which the principal commodities are the following:

a. Tomato paste

b. Canned, peeled tomatoes

c. Dried tomato slices, tomato powder and tomato flakes

d. Deep-frozen tomatoes, either whole or in pieces

e. Tomato juice and tomato sauce

Tomato processing in Mali

Mali's history of processing tomatoes has been uneven. Since independence, there has been only one processing plant for tomatoes and other fruit. Installed in 1964, the Société des Conserves du Mali (SOCOMA) was a state-owned enterprise located in Baguineda, constructed with funds provided by the Government of Yugoslavia. The processing plant had two processing lines: one for processing tomatoes into double concentrate, and one line for mango pureé. The objective was to produce tomato paste to substitute for paste imports and to add value to surplus mango production that would have otherwise have been lost; and to market these finished products into local markets. In 1970, SOCOMA installed a processing line for fruit juice production from tropical fruit, including mango and tamarind.

Management and technical difficulties led to the partial privatization of SOCAMA in 1978, and a new enterprise was formed under the name Société des Conserves Alimentaires du Mali (SOCAM), a mixed company with 90 percent of its capital held by the Government of Mali (GOM) and 10 percent held by a French private company.

SOCAM was in existence for only two years. In 1980 the company was registered as a private company, and its name was changed once again to Société Malienne des Conserves, SA (SOMACO). The new company's ownership was GOM – 10 percent, Malian private operators 40 percent, and the French group, 40 percent.

SOMACO continued with little progress into the 1990s, and in 1995 the French partners gave up their ownership. In 1997, under its Agribusiness Development project, USAID supported a program by the *Office de Haute Valle du Niger* to organize its farmer groups to produce 850 tons of tomatoes for processing by the factory. Around 3,500 small farmers participated in the effort. Despite these efforts, SOMACO finally closed its doors in 1998. Many of the small farmers who produced industrial tomatoes for SOMACO have continued growing fresh tomatoes for urban markets in Mali.

Potential for using science and technology as tools for renewing the processing tomato sub-sector in Mali

The following are science and technology (S&T) and key research activities that can potentially support the renewal of a processing tomato agro industry in Mali. Most of these concepts are applicable to virtually all agro-food processors:

a. Market research: The potential investor should conduct market research to determine the potential size of the market for processed tomato products in Mali, as well as the specific products that have the greatest demand, and the specifications for those products. For example, it was reported that SOMACO's products were pale compared to the rich, red color of the imported Italian tomato paste, which the Malian consumer preferred. This placed SOMACO's products at a market disadvantage. Research should also be conducted to determine the potential for exporting tomato products produced in Mali to regional markets.

b. Technology and equipment: The potential investor should select the technology and equipment that is most adaptable to the field conditions in Mali. For example, in view of the general difficulty of equipment repair and maintenance in Mali, it would likely be wise to choose equipment that is relatively easy to maintain. Equipment capacity will, of course, be guided by the availability of investment capital and the results of market research.

c. Volume of tomato production: Let us assume that the potential investor assumes that market demand is 5 kilograms of tomato paste per capita for Mali's 4 million urban residents and one kilogram per capita for its 8 million rural residents. Total annual demand would be 28,000 tons of paste, corresponding to 140,000 tons of tomatoes. All the tomato paste consumed in Mali is presently being imported. If the investor calculates that he or she could capture one-half the total annual demand of 14,000 tons of paste (corresponding to 70,000 tons of tomatoes), then the factory processing capacity should be scaled up to approximately 100,000 tons of tomatoes. Since most tomatoes are cultivated during the "contre-saison" and the annual harvest occurs during April-May-June period, considerable work will have to be done to spread the tomato harvest period over a longer period. Otherwise, the flood of tomatoes during the brief harvest period will greatly exceed the factory capacity.

d. Timing of harvest: To avoid exceeding the factory capacity even under a two-shift operation, the annual tomato harvest should take place over a minimum period of six months, and preferably longer. This will require staggering the planting so the annual harvest period occurs, say, between October - May. Extending the production season will

require considerable adaptive research to select and test plant varieties that can be planted for harvest during the extended time period. Such a project could easily be carried out by ON with the support of the Institut d'Economie Rurale (IER), with possible funding from USAID.

e. Production source: If given the choice, most tomato processors would like to directly control approximately 35 – 40 percent of their raw material supplies, and contract with outside growers for the remaining amounts. To produce the annual requirement of 70,000 tons of tomatoes would require a production of 2,000 hectares, assuming an average yield of 35 tons per hectare. Under this scenario, the processing plant would obtain a long term lease for a maximum of 700 hectares, and use this area as a "mother farm". It would contract with local farmers to produce tomatoes on an additional area of 1,400 hectares of "satellite" farms. The satellite farms would be operated by experienced small farmers within the irrigated area within range of the processing plant. This arrangement would ensure the rapid dissemination or production practices and technology put into practice at the mother farm, onto the satellite farms as well. If it was not possible to develop an entire, large-scale "mother" farm, then a smaller, "model" farm should be operated commercially by the investor, for the purpose of demonstrating appropriate agricultural practices. In this case, the entire production volume would be provided by small farmers under contract with the factory. In either case, technical staff from the IER and the ON should be involved in the design and establishment of research and development plots on the mother (or model) farm, and for transferring the knowledge gained to the small tomato producers.

f. Planting material: High yielding plant varieties combined with intensive agricultural practices under irrigated conditions are critical elements in the economic success of a tomato processing agribusiness. In addition, as described earlier, the production season must be extended for a longer period during the year to smooth the production curve for efficient factory operations. For these reasons it will be necessary for the tomato processor to establish and operate a plant nursery to produce tomato plants for distribution to the contracted small farmers. In this manner, the processor will control the timing of planting, the plant varieties, and the seasonality of production.

g. Pest and disease control: Yellow leaf virus (TYLCV) is a major problem for tomato producers in Mali, and was cited as one of the factors that led to the closure of the SOCAMO factory. This virus reduced crop production to the extent that few tomatoes were available for processing. While considerable work has been done by IER on selecting and testing virus-resistant varieties, much work needs to be done in this field. Developing the means to control the virus and/or to develop virus resistant plants would be a major element of a processing tomato agribusiness in Mali. Other prevalent pests and disease problems affecting tomatoes can be controlled through appropriate agriculture practices.

h. Contracting mechanism: Small farmers should be contracted to provide a specified, minimum quantity of processing tomatoes at a specified price, with the possibility that additional quantities produced might be purchased by the factory. Also, the farmers should be encouraged to produce additional amounts of processing tomatoes to be sold into local markets. It would be to everyone's advantage – the factory, as well as the small farmers' – that the local market for fresh tomatoes be fully supplied with industrial tomatoes, so that the local market price would be approximately in line with the factory price. That way, there would be little price incentive for the farmers to divert production from the factory into local markets.

i. Credit: Similar to the practice that prevails in the cotton industry, it may be required that the processor provides farm inputs to all its contracted small farmers. However, for commercial reasons it would be much more desirable if farmers' village groups and associations could obtain seasonal credit from the banking sector or micro-credit associations for its members, on the basis of the tomato purchase contract between the farmers' association and the processing plant. Otherwise, in-kind credit as farm inputs must be provided by the processor to the farmers, with their values deducted from the amounts paid to the farmers for tomatoes delivered to the processing plant. This practice will normally create a problem for the processor, since it is in the individual farmers' short-term interest not to deliver his or her tomatoes to the processing plant; instead, to sell the tomatoes on the local market even at lower prices, since no deduction for inputs is made from local market sales. In the event that the processing plant is required to provide farm inputs, it would be wise to have a collective agreement with the farmers' association, instead of individual farmers. In this manner, some degree of protection would be provided to the processing plant to ensure repayment for inputs and the delivery of contracted amounts of processing tomatoes through group solidarity.

j. Value of production: For competitive reasons the business of food processing is normally characterized by low unit margins and high unit volumes. To be competitive, a tomato processor in Mali must be capable of producing tomato products of equal quality, and at a cost that is no greater than the cost of imported products. While there is some degree of tariff protection[2] provided to processors located within the West African Economic and Monetary Union (WAEMU), there is also a possibility that "leakage" may result in lower-cost products imported illegally, as is reported to be the case for imported sugar.

As shown by the following table, the landed cost of tomato paste imported into Mali from Italy, the nearest low-cost producer, is estimated to be US $2.25 per kilogram. This is the maximum amount that a tomato processor in Mali could charge if it is to remain cost competitive with imported paste.

Estimated delivered cost of imported tomato paste

Item	Cost (US$ per kilogram of paste)
Processing tomatoes (1)	0.25
Manufacturing costs and margin	1.00
Transportation to Mali; handling	0.25
Import duties	0.75
Total	2.25

(1) In Europe, on average, 5 kilograms of processing tomatoes are required to make one kilogram of tomato paste.

The cost assumptions are the following: the cost of 5 kilograms of industrial tomatoes at US $.05 each, or a total of US $.25; the cost of producing one

[2] Processed food items are assessed a duty of 60 percent.

kilogram of paste, including manufacturers' margin, is US $1.00; transportation cost to Mali is US $4,000 per 20-ton container, or US $.20 per kilogram; import duties amount to US $.75 per kilogram, and handling charges amount to US $.05 per kilogram.

Despite the cost advantage of a manufacturing processing in Mali that is not subjected to import duties, however, much of the cost benefit will be eaten away by higher manufacturing costs. This is due to the requirement to import cans and labels, and greater processing costs caused by high electricity rates in Mali. To be cost competitive with imported tomato products, it will be necessary place a ceiling on the cost of tomatoes used as raw materials. Approximate manufacturing costs for tomato paste in Mali will be the following:

Estimated cost of manufacturing tomato paste in Mali

Item	Cost (US$ per kilogram of paste)
Processing tomatoes (5 kilograms)	0.50
Manufacturing costs	1.50
Taxes and profit margin	0.25
Total	2.25

Under this example, given the price ceiling imposed by imported tomato paste, the maximum amount that the factory can pay to the farmers for processing tomatoes is the equivalent amount of US $.10 per kilogram (50 FCFA per kilogram), or US $.50 for 5 kilograms of tomatoes that are required to manufacture one kilogram of tomato paste.

However, the small Malian farmer who currently produces limited quantities of "contre-saison" tomatoes on irrigated farmland sold as fresh fruit into local markets enjoys higher prices, on average, than the processing plant would be willing to pay. Based on a recent study by the Mali Finance Project[3], small farmers, on average, produce 0.2 hectares of fresh tomatoes for self-consumption and for local sale, which are sold at an average price of 75 FCFA per kilogram. Their average production yield is 17.4 tons per hectare. As shown by the following table, for small farmers to obtain about the same income per hectare from selling industrial tomatoes to the factory at a lower price than they can obtain by selling fresh tomatoes into local markets, their production yield must approximately double, to around 36 tons per hectare.

Determination of Farmer's Yield to Maintain Income at Lower Price

Item	Fresh market production	Industrial production

[3] *Le Risque du credit agricole dans les zones de l'Office du Niger et de la CMDT*, 27 septembre, 2004

Production yield: tons per hectare	17.4	36.0
Revenue per kilogram (FCFA)	75	50
Total revenue per hectare (FCFA)	1,305,000	1,800,000
Costs per hectare (FCFA)	389,350*	864,000**
Revenue per hectare (FCFA)	915,650	936,000

**ibid.* ***Author's estimate*

Note that to achieve a yield increase of 106 percent, costs must increase by 122 percent. The reasons are because to achieve greater yields, proportionally greater amounts of inputs are required, and additional non-family labor is needed, at a higher unit cost than family labor.

The table illustrates that the success of tomato processing is dependent on improving the average production yield to ensure that the small farmers' incomes are maintained, and that the factory can maintain its competitiveness in the face of imported processed tomato products. This not only will require careful management of the entire production process, including the availability of irrigation water, as well as using the latest production technology to ensure that high yields are achieved. This effort merits the support of USAID, through ON and IER.

Summary

The preceding discussion was intended to highlight the team's belief that there is no technological "quick fix" that will have a dramatic effect on reducing poverty in Mali. Instead, the judicious application of science and technology in support of sound management, combined with private investment for economic growth and job creation, is the recommended approach.

For example, USAID might support the development of a processing tomato agro industry in Mali by sponsoring a feasibility study complete with an operating plan that brings together all the science, technology, research and extension services to support the venture, and promote the opportunity among local as well as international investors.

Donor project resources can be of enormous value to reduce the risk to private investors in locations such as Mali. First, project resources can be used to help create or strengthen a value chain for marketable products within a chosen agro industry. Project interventions must be structured to support the weak links in the value chain. Normally, what this means is that the producers must be helped to produce the product with the quality, quantity and consistency of supply that the market requires. Another way to look at it is that project resources are used to reduce the risks run by the risk takers who choose to participate in this venture.

It is unfortunate, but dealing with small producers normally increases transaction costs because they are too small, too inefficient, have irregular production times, and more often than not, attempt to sell low quality products. Consequently, project resources must be used to help producers overcome quality and supply problems and to combine their output for greater efficiency. In this manner, the risk of market failure due to poor product quality and timing will be considerably reduced.

Creating a value chain in a developing location is normally an iterative process, because there are interlocking constraints that have to be overcome. This is a bit like peeling an onion. As you remove one layer, or solve one problem, there is another layer, and another problem, directly underneath. Work must be done to remove the major constraints that limit the efficient functioning of the value chain.

A second means for donor projects to increase private investment is to reduce the financial risk to the investor. Under this process, risk capital provided by a donor acting as a silent partner in a sound investment within a key sector can reduce the financial risk to a tolerable level for a private investor.

USES OF SCIENCE AND TECHNOLOGY TO EXPAND THE LIVESTOCK SUB-SECTOR

Livestock is of great importance to Mali's economy. Livestock accounts for around 12 percent of Mali's GDP and a little more than 17 percent of national exports. It is the third most important export commodity after cotton and gold. Undoubtedly, due to its importance, numerous analyses have been made of the sector, and its related sub-sectors including meat, milk, hides and skins. Many plans and strategies have been formulated for livestock development in Mali, as well as for its sub-sectors. This report does not provide an additional analysis of the sub-sector. Instead, it provides recommendations on the use of science and technology for the advancement of the sub-sector, and for animal feed, its related agro-industry.

The recommended interventions are made for the purpose of overcoming the major constraints that retard the growth and development of this sector. These constraints are the following:

a) Livestock breeds are not highly productive

b) Animal health is a problem, given Mali's tropical climate

c) There is a need for low-cost, high quality, balanced animal feed

d) There is limited capability to market live animals, and to transform and market animal products.

Recommendations for expanding the livestock sector in Mali

1. Increasing the productivity of livestock breeds: More productive breeds of livestock require the manipulation of genetic material so that future generations produce more milk or meat, or in the case of poultry, more eggs or meat. In locations such as Mali, it is normal to cross-breed stock that is well adapted to the local environment with higher-producing, imported stock. For livestock, there are two standard methods for improving the genetic stock: cross-breeding and selection (inbreeding); both methods can benefit from the following four biotechnological tools:

a. Artificial insemination (AI): Semen from males of highly productive breeds is used to impregnate females of local breeds so that the offspring will have greater productivity and can thrive under local conditions. Artificial insemination was introduced in Mali in the colonial era using fresh semen. The use of frozen semen, stored in liquid nitrogen, started in 1964. Up to the present, AI has helped produce about 8,000 crossbreds around Bamako from three European breeds (Montbéliarde, Friesian and Rouge des Steppes), and is estimated to have increased by 60% the availability of fresh milk in Bamako. A cross-bred cow produces about double the amount of milk as a local cow.

Higher producing breeds have much higher input and care requirements than local breeds. As such AI may not be a useful technology for the traditional pastoralists who use extensive, low input production. However, it may be more useful for the richer agro-pastoralists, who are moving towards livestock intensification and agriculture/livestock integration

Although AI is a well-established and accepted technology, it is used in less than one percent of breeding females. The difficulties are related to semen provision, liquid nitrogen supply where the semen must be stored, (expensive and not always available), high costs and limited availability of other inputs such as hormones. A big drawback is that one successful AI costs about US $120, which is too expensive for all but the richest farmers. The problems of liquid nitrogen cost and availability may be overcome by using fresh semen from bulls kept by the farmers or farmer's cooperatives, but this would require keeping pure exotic breeds in the tropics which is expensive and difficult. However, by having breeding bulls available the farmers could

avoid the cost of applying hormones to the females as a means to manipulate the time of conception, and considerable cost savings would result.

While AI technology is well known in Mali, donor intervention is needed to improve the supply and the efficiency of its delivery so that its per unit cost can be reduced to a level that small farmers can afford to pay. This would have a rapid impact on breed improvement.

One particularly progressive farmer that team members visited, Mr. André Ndiaye of Toulomajo, has a purebred Holstein bull at his farm from which he is planning to sell semen, as well as offspring from the Holstein crossed with the local breed of Zebu Maure females. This private sector approach to breed improvement should be encouraged.

b. Embryo sexing and cloning, multiple ovulations and embryo transfer (MOET):

These techniques involve manipulation of embryos. Embryo sexing allows specialised dairy or beef herds to produce only the economically important sex (cows for dairy herds and bulls for beef herds). Cloning allows rapid improvements in genetic potential as high potential embryos can be implanted in local dams. Through multiple ovulations and semen storage, the same parents can produce multiple offspring that are carried by local dams.

No current activities related to MOET are taking place in Mali. It is recommended that IER be supported in its development of these capabilities.

c. Open Nucleus Breeding System: In traditional pastoral systems, the open nucleus breeding system (ONBS) is one of the best options for genetic improvement. The concept of ONBS is based on a scheme where a nucleus herd is established under controlled conditions to facilitate selection. The nucleus is established from the "best" animals obtained by screening the base population (group of herds or farms) for outstanding females. The nucleus is used through MOET with superior males to produce embryos, which will be carried by other females in the base population. The male offspring are reared and evaluated as appropriate. From those, an elite group of young males with high value for their specific traits are selected and used in the base population for genetic improvement through natural service or AI.

A major limitation of ONBS is the long delay before achieving the expected genetic improvement due to slow reproduction rate, especially in cattle. Biotechnology can help reduce this limitation of ONBS programs through the use of multiple ovulation and embryo transfer. No ONBS practices are being made in Mali. It is recommended that IER be supported in its development of these capabilities.

d. Genetic markers and marker assisted selection (MAS): The process of selection for a desired trait (e.g. for production or disease resistance) can greatly benefit from using genetic markers. This is known as marker assisted selection (MAS). MAS can accelerate genetic progress by increasing the accuracy of selection and by reducing the generation intervals through the use of young females. Genetic markers for some production traits and for resistance to certain diseases are known and the corresponding genes can be introduced into a population for its improvement. It is also recommended that IER and other relevant institutions be assisted to develop these capabilities.

Participating institutions: The Institut d'Economie Rurale (IER) is the institution in charge of research on animal reproduction, genetics and nutrition. Current IER Livestock research projects are grouped into 3 programs according to species: bovine, small ruminants (sheep and goats) and poultry. Other institutions with an actual or potential interest in research in the area of animal production are the "Institut Polytechnique Rural de Katibougou (IPR) and the "Laboratoire de Biologie Moléculaire Appliquée" of the faculty of science and technology (FAST) both under the University of Bamako which play a crucial role in the training of young scientists and could be

involved in IER and CVL research projects as scientific partners. These institutions should be supported as appropriate in implementing the above programs to improve livestock breeds in Mali.

2. Using science and technology to improve animal health

The Central Veterinary Laboratory (CVL) is the only institution with significant capacity for research on animal health in Mali. Established thirty years ago with USAID funding, it contributes to animal health through disease diagnosis, surveillance and prevention, and applied research in the field of animal health and production. It also contributes to public health through zoonotic diseases diagnosis and food safety analyses. It trains veterinary personnel in the field of laboratory techniques, and conducts pesticide residues analyses for water, feed, and plants.

The CVL is made up of two specialized units: a) a *diagnostic and research unit* comprised of 10 specialized laboratories, plus a laboratory animal house and experimental farm to support its activities; b) a *vaccine production unit* , which is a large complex of laboratories and rooms devoted to the production of bacterial and viral vaccines and vaccine quality control

The CVL's human resources include 23 scientists, 23 lab technicians and 8 veterinarians, along with sufficient support staff for current programs. Most of the scientists have had short - term training on specific biotechnological techniques; a certain number of scientists have a more comprehensive background in biotechnology.

There are three recommended actions using science and technology to improve animal health in Mali:

a) Enhance the Government of Mali's (GOM's) institutional capability to develop and to apply biotechnology as a tool for improving animal health. The urgent needs are primarily those of capacity building and institutional development at CVL, and finalising a regulatory framework within Mali that takes into account animal biotechnologies. This framework should be appropriate for the country and harmonised regionally and internationally

b) Only one truly biotechnological research program is underway at CVL. This is production of a recombinant vaccine against contagious bovine pleuropneumonia (CBPP) in a partnership with four other laboratories in South Africa, Portugal, Switzerland and France. This effort is led by the International Centre for Agricultural Research for Development (CIRAD), of France, with funding by the European Union (EU). There is a need for a related project to develop a recombinant vaccine against contagious caprine pleuropneumonia (CCPP). This is an important effort and merits international donor support.

c) Although some vaccines produced by traditional approaches have had a great impact on disease control (especially for Rinderpest eradication), biotechnology can improve disease prevention through the production of improved vaccines, and from the use of thermo-tolerant vaccines. In Mali, where cold chains are difficult to maintain, the development and improvement of thermo-tolerant vaccines is a priority. Biotechnology applications are available for production of thermo-tolerant vaccine for Newcastle disease, and for *pestes des petits ruminants* (PPR).

3. Animal feed production:

Almost all analyses that have been made of Mali's livestock sector agree that the lack of low cost, balanced feed rations is a major constraint to the industry. Not surprisingly, the main sources of feed are by products from the major processing operations of cotton ginning and grain milling. However, users complain that first, these items are in short supply, and second, while the products make good feed inputs, they do not provide balanced rations. The reason is because feed supplies are driven by the availability of their available raw materials instead of the feed

requirements of the animals being fed. Consequently, the existing feed formulations are not balanced to the needs of the animals. While the technology for formulating balanced feed rations is readily available in other locations, it is not being used in Mali.

The main limiting factor for manufacturing animal feed from local ingredients is the absence of a low-cost source of protein. Soybeans are an ideal source of protein, and can be grown in Mali as a rotation crop. Animal feed rations could be mixed from soybeans, along with grain crops such as corn or sorghum, or with cotton by-products. With the availability of low-cost balanced rations, it would be possible to a) improve the value of export livestock, b) enable animals to be fattened efficiently while being held at feedlots prior to slaughter, c) increase the amount of fresh milk produced, and d) expand the number of poultry farms available for producing eggs as well as low-cost broilers for meat production.

The following recommendations are put forth as a means to develop the animal feed agro-industry in Mali:

a. Develop investment analyses, cash flow projections, and a market analysis of the Malian market for animal feed, and provide these as investment proposals to potential investors in an animal feed manufacturing venture.

b. Provide hybrid soybean seed, technical assistance and training in soybean production as a rotational crop under irrigated, as well as rain fed conditions, to the technical staff at IER. Help to pilot production plots, along with a model milling operation.

c. Provide animal feed formulation programs to the technical staff at the Institut d'Economie Rurale (IER), feed companies, private veterinarians, and international donor organizations engaged in livestock production, and provide training for their use.

d. Provide assistance to IER to develop training programs for livestock owners on the economic benefits of supplemental feeding with balanced rations, and the development of feeding formulas.

e. Provide assistance to the IER and the animal feed certification laboratory in Sutuba to develop grades and standards for animal feed. Standards for animal feed products need to be established to enable the sale of feed on the basis of product quality.

f. As a separate but related item, animal owners can supplement the use of commercial animal feed by growing hay and fodder and storing these products for use when little vegetation is available. The relative benefit of growing hay within irrigated areas should be explored, and if economically viable, the ON should be encouraged to open irrigated areas to the production of animal feed, instead of its major focus on rice. An alternative would be to use hay as a rotation crop, instead of corn. One veterinarian who was interviewed by the team expressed the opinion that growing hay would be provide twice the economic benefit as rice, in irrigated areas.

Marketing live animals, and transforming and marketing animal products

The export marketing of live animals and the production and marketing of meat products are private sector activities that should be encouraged and strengthened, primarily by providing information and technical assistance. Little *research* is needed to strengthen these sectors; what is primarily needed is the *application* of technology that is available in other locations.

Improving the export marketing of live animals

Markets for livestock are highly fragmented, and are characterized by numerous transactions from the time an animal is sold by its original owner until the time it is purchased by its final buyer. Transportation of animals is expensive throughout Mali and from Mali into neighboring

countries. There are no market standards within Mali for the inherent quality of an animal for its meat-producing ability. Shipments to the neighboring countries of Ivory Coast and Senegal are reportedly marked by illegal taxes levied along the way. Markets exist in other countries, including Ghana, Nigeria, Gabon and Guinea, but they are not exploited by livestock owners.

The following are recommended uses of appropriate technology applications to help expand animal exports from Mali:

a) Work to create a livestock exporters' association as a means to disseminate information, as well as to represent its members, particularly for combating illegal taxes on animals during transit.

b) Encourage the establishment and use of feedlots in regional towns where animals can be penned and fed. Presently, animals lose up to 30 percent of their body weight during the dry season when little vegetation is available. Feedlots can also serve to fatten animals before sale.

c) Provide information and contacts to exporters on additional livestock markets in Senegal and the Ivory Coast, and provide new market contacts in other neighboring countries.

d) Establish animal health certification as a pre-condition for export.

Improving the export marketing for raw meat: Presently, exports of livestock products from Mali consist only of shipments of live animals. There are no exports of meat or meat products, so there is no value-added in Mali, which would provide employment. In general, facilities for slaughtering animals are rudimentary and raw meat is stored in the open air until sold. Refrigerated facilities for storing meat are almost non-existent. The lack of refrigerated transport severely limits the sale of raw meat as a value-added export product. However, there is a good market for red meat in Mali, as well as in neighboring countries. It will be up to Malian exporters to capture those markets.

The following are recommendations on the use of technology to stimulate the export of raw meat by the private sector:

a) Determine the competitiveness of raw meat from Mali delivered and sold into different major markets within the sub-region. One recent report[4] concludes, for example, that the delivered cost of raw meat into Abidjan from Mali is 10 – 15 percent higher than the cost of similar meat produced locally. A factor that may limit the competitiveness of raw meat exported from Mali, compared to the export of live animals, is the greater value that is placed on animal by-products, particularly in coastal areas. Since only the carcass is exported, by products are not included as part of the item sold.

b) In those locations where meat from Mali proves competitive with other suppliers, provide the potential exporters with market information and market contacts.

c) Develop investment profiles and cash flow analyses for meat exports, and provide this information to the potential exporters

d) For export products, establish a procedure for certifying the health of the live animals before slaughter, and the resulting meat products after slaughter.

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[4] CENTRE AGRO ENTREPRISE : *ETUDE POUR LA PROMOTION DES FILIÈRES AGRO-INDUSTRIELLES ANALYSE DE L'ÉTAT DES FILIÈRES DE L'ÉLEVAGE*, BAMAKO, FÉVRIER 2001

e) Create a cold chain for chilling and storing fresh meat, and for transporting fresh meat to export markets.

Improve the transformation and marketing of animal products: Presently in Mali, the only commercial processing of meat products is that which occurs on a daily basis by butcher shops that convert animal carcasses into cuts of meat. The main factors limiting meat processing are the lack of storage facilities for perishable finished products, and the lack of technology for processing meat products.

While there is a major processor of milk products in Mali, the vast majority of the raw material that is used for processing into milk products is imported powdered milk. The percentage of local milk used for making processed milk products is very low. The main limiting factor is the inability of the factory to collect and store raw milk for processing.

The recommended approach to improve the transformation and marketing of animal products is first, to support the development of agro-industries for processed livestock products, and second, to improve the transformation and storage of animal products for home use by individual families.

Support the development of agro-industries for processed livestock products: The food technology laboratory at the Ministry of Agriculture's research center at Sotuba has done considerable work in developing recipes and technical instructions for preparing nectars and syrups from fruit, dried fruit and vegetables, cereals, and milk products. However, due to budget limitations, the laboratory has not been able to adequately disseminate information about its technology. The laboratory should be assisted to develop additional recipes and technical instructions for commercially important products, and provided the means to widely disseminate the information. Potential small and medium-scale entrepreneurs that want to use the information to create a business should also be provided technical assistance in business development.

Technical support to increase the collection of fresh milk: Technical support should be provided to Mali Lait to enable the collection of fresh milk over a broader area, through the use of regional collection centers where milk can be held under refrigeration, and transported to the processing plant by refrigerated carriers.

Support home processing and storage of food products: The food technology laboratory, as well as IER should be assisted to provide training and technical support to farm associations, rural and village groups in improved methods of processing and storing food in the absence of refrigeration. This work would support activities such as home canning of fruit and vegetables, drying techniques for fruit and vegetables, meat preservation through drying and salting, and cheese making at the village level.

MANGO SUMMARY

Mango is a highly promising export product for Mali. Mali enjoys a three-month market window in Europe during the period from late March until mid July when competing producers from South and Central America and South Africa have low export volumes. During Mali's market window, its export potential is 50,000 tons. Mali's production season is complementary to that of Senegal, which begins before Mali's season ends, and continues into the fourth quarter of the year. If Malian and Senegalese producers could jointly supply the EU market in a coordinated manner for an entire six-month period, then both groups would greatly benefit by an enlarged market presence.

There are two major mango producing locations in Mali. One is located in the region surrounding Bamako and to the west of the city, and the second is in the south, near Sikasso.

There are two means of transport to European markets. One is by air freight from the Bamako airport to European markets, mostly in France. However, this has a high cost and is mostly suited for relatively low volume, niche markets that bring high prices for early-season varieties such as Amélie. The second means of shipment is by container through the ports of Dakar, Senegal, or Abidjan, Ivory Coast. Exporting through Dakar is highly preferable since transit time from this port to Northern Europe is only 8 days, compared to 12 days from Abidjan to northern Europe. However, the road between Bamako and Dakar is in extremely poor condition, and shipping a container of mangos by truck overland is a two-day journey. Truck transport is also expensive – around 30 percent more costly than rail transport. The railroad serving these two cities was privatized in 2002, but thus far, the rail service to Dakar is not sufficiently reliable to build a commercial export program around rail transport. The travel time by rail is four days.

Shipping by sea is becoming progressively more important. From a base of only one 20-ton container shipped in 2000, during the 2004 season almost 1,500 tons were shipped by sea. Sea shipments are made primarily to northern Europe, to discharge ports in Holland and Belgium. Sea transport is providing access to North European markets for Malian mangos. Without sea transport, air shipments would continue to be limited to only a few hundred tons during each season.

There are a number of constraints to mango exports from Mali. The following is a description of the most important of these:

a) *Certification*: This refers to the requirement to certify mangos under Europegap rules, and to ensure the traceability of mangos shipped into Europe. Europgap refers to a set of procedures to ensure food safety without environmental degradation that are sponsored by most major importers and distributors of fresh horticultural products in Europe. These rules went into effect at the beginning of 2005, and must be met by exporters who sell fresh fruit and vegetables to these importers and distributors. These require that each field where export mangos are harvested must be identified and geo-referenced using a Global Positioning System (GPS), and that individual cartons of mangos be identified by a bar code. This enables the identification of the field where the mangos are produced, and makes it possible to trace the product from the European retailer back to its original source. In addition, good agricultural practices must be followed by farmers and packers, and strict post-harvest procedures must be followed to ensure the health and safety of the consumer who buys the product at retail. An external certifying organization must certify that the entire farming, packing and export operation is in compliance with these standards.

b) *Productivity of orchards*: Most mangos produced in Mali are from ageing trees, and the greatest production is from native varieties that are not marketable overseas. There is a need to rejuvenate orchards by grafting commercial varieties that are suitable for export, and thereby capitalize on the market window that Mali has for EU markets.

c) *Lack of cooling and cold storage facilities*: With the exception of one large exporter near Sikasso, there is no "cold chain" for mangos in Mali. As is the case for all fresh products, mangos must be chilled soon after harvest and stored at their optimum, cool temperature to extend their shelf life and to minimize post-harvest losses. This requires chilling equipment, refrigerated warehouses, and refrigerated transport. This equipment is not available to most mango exporters.

d) *Lack of packaging material and supplies*: Presently, within Mali, there are no manufacturers of packaging material that is needed to export fresh products, such as carton boxes and cushioning material. Almost all the packaging material for export mangos is presently being imported from France. Also, there is a lack of wooden pallets, which are required for fruit and vegetable exports. Pallets make it possible to move large stacks of boxes filled with mangos efficiently, using a forklift machine. The pallets that are used for mango exports must be imported from the Ivory Coast.

e) *Lack of skills required to produce export-quality mangos*: European importers and buyers desire mangos that are of the appropriate variety, and that are homogeneous in size, color, shape, maturity, and are free from blemishes. Malian exporters require training and discipline to ensure that the European industry standards for product quality/appearance are met by all shipments of mango exports. For example, during the 2004 season many shipments were considered deficient due to uneven fruit maturity, insufficient fruit color (too green), external scars and blemishes caused by anthracnose disease, improper packaging, improper use of pallets and crushed boxes. These problems result in unhappy customers and, quite often, reduced prices.

f) *Weak and fragmented mango exporters*: With the exception of one large exporter near Sikasso, mango exporters are mostly traders who buy and sell a number of products, including mangos. Their professional expertise is highly limited. There are three exporters' associations in Mali, whose institutional capabilities are also limited. However, the three associations are in the process of merging into a single, stronger organization. With institutional support to the new organization it could evolve into a dynamic force to develop the mango industry in Mali.

Mango exports are supported by the USAID-funded project, Mali Trade. This organization is assisting eighteen mango exporters, the majority of which are small-scale exporters who deal with a range of products, including mangos. However, one exporter is a large-scale, professional agribusiness operator from the Ivory Coast who has formed an alliance with Malian orchard owners to export mangos from Mali. The joint operation is operating near Sikasso, in southern Mali, and last year had an export volume of approximately 1,500 tons. This highly professional operation has refrigerated storage for mangos, and ships its product by refrigerated transport from Sikasso to Abidjan, where they are loaded aboard ship for transport to Northern Europe.

Mali Trade provides technical assistance to mango growers to help improve the fruit quality and quantity; it supports marketing and export logistics, and it provides market information to the exporters. With the assistance of Mali Trade, mango exports in 2004 reached the level of 2,300 tons, the highest in recent years.

The Mali Trade organization is working to organize a cold chain with refrigerated transport from Bamako to Dakar by rail or by road, and from Bamako to Abidjan. During 2005 the Dutch

government has pledged to provide funding to Mali Trade for a chilling facility and refrigerated storage at a location near Bamako. This will not only serve mango exporters, but also will enable the export of papayas to European countries, as well as onion and potato exporters to countries within the sub-region.

VISIT TO LABORATOIRE DE TECHNOLOGIE ALIMENTAIRE

On February 28, 2005, one of our team members visited Mme. Cisse Oumou Traore who is head of the Food Technology Laboratory (FTL) at the Sotuba research station, near Bamako. The FTL forms part of the Institut d'Economie Rurale, within the Ministry of Agriculture. The following is a summary of the discussion with Mme. Traore:

- The objectives of the FTL are a) to provide technical support to the Institut d'Economie Rurale, and b) to improve the traditional processing technology for transforming cereals, fruit and vegetables, and products of animal origin. An overview of the laboratory's functions is included in Appendix I.
- One of the objectives of the laboratory's work on cereals is to substitute local grains including sorghum, millet, and corn for imported wheat, as inputs for bread and cracker products for human consumption.
- The laboratory also does quality analyses on finished and semi-finished food products.
- The laboratory produces commercial products such as pickled vegetables, fruit juice, fruit jams and jellies, and dried fruit and vegetables that it sells to hotels and supermarkets in Bamako. It has developed formulae and manufacturing techniques for all its products (Appendix II).
- The laboratory informs the public about its findings and product opportunities through seminars that are held at the laboratory. Mme. Traore recognizes that this practice is not highly effective as a means for communicating the laboratory's results to the public. She would much prefer to have in place a means for "vulgarization en cascade" where field training is done by trainers at the village level, supplemented by television and radio programs describing and showing how food processing can be done. This method was used under the World Bank-funded project, the "Programme Nationale de Vulgarization Agricole". However, this program no longer exists.
- Despite the laboratory's limited means for communicating, Mme. Traore stated that more than a dozen small-scale food processing enterprises have become established in the region, as a result of the work done by FTL.
- The only vegetable that is preserved in substantial quantities by drying is gombo (okra). However, two other highly perishable vegetable products that are consumed in large quantities in Mali are tomatoes and onions. Mme. Traore believes that by developing appropriate drying technology for these two vegetables, they could be stored for consumption when they are not in production. During the height of the production season, the price for tomatoes, for example, may fetch as little as 750 FCFA for a 100-kilogram basket, equivalent to only 7.5 FCFA per kilogram. While it is possible to dry tomatoes as well as onions, traditional drying methods result in a change in color, which makes them unsuitable. Mme. Traore believes that the color change may be caused by the use of fertilizer, but is not sure of the actual cause.
- Mme. Traore participated in a study sponsored by UNIDO to define what action needs to be taken to improve food processing for commercial purposes, as well as a tool for food storage. The study is shown in Appendix III.

Conclusions:

a) According to International Trade Statistics, in 2001 Mali imported wheat valued at US $12.7 million, and different flour products with a total value of US $8.4 million. The total value of imports of these two commodity groups is around US $21 million. By substituting the consumption of local grains such as sorghum and millet for the consumption of imported wheat or flour, Mali's farmers would be better off, and the nation's trade balance would improve. Thus, the work by FTL to substitute local grains for imported wheat merits support by USAID and other international donors.

b) In view of the heavy post-harvest losses of fresh vegetables due to poor handling and storage practices, work by the FTL to develop drying technology for vegetable such as tomatoes and onions merits strong support by USAID and other international donors.

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